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**Analysis of R/V Albatross IV- F/V Sea Breeze
Trawl Configuration Experiment**

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Introduction

Experiments designed to test the effects of alternative gear configurations and designs or for the purpose of intercalibration of research and/or commercial vessels have been widely applied (e.g. Bergh et al. 1990; Pelletier 1998). Comparative fishing trials have been an integral component of the survey program at the Northeast Fisheries Science Center to test for differences in research vessels and survey gear (reviewed in Pelletier 1998). Intentional or unintentional modification of gear or survey procedures can have important implications for the integrity of time series estimates of abundance derived from these surveys. Accordingly, careful analysis of any change in the survey characteristics is essential.

In the autumn of 2002, an error was discovered in measurement of trawl warps used during surveys by the NOAA R/V Albatross IV. An experiment was conducted during the period October 28 - November 6, 2002 to test the effect of the trawl warp offset and other aspects of gear configuration identified by industry representatives. Here, the results of this experiment are provided. See (Almeida 2003) for an overview of the operational protocols for the experiment

Experimental Design

To test the effect of changes in survey gear and the trawl warp offset, a randomized complete block experiment was designed. Bergh et al. (1990) provides an overview of the application of this design in comparative fishing trials. The NEFSC had earlier employed this design for the purpose of testing gear and vessel effects off the Northeast United States (see Pelletier 1998). For the purposes of this analysis, the control was taken to be a gear configuration comprising a newly constructed net built to original design specifications, balanced trawl doors approved by industry representatives; and correctly marked trawl warps. The treatment comprised use of an existing net randomly selected from the NEFSC inventory, a set of doors identified by industry representatives as problematical, deliberately twisted backstraps, the currently used 'traveler' attachment configuration, and deliberately offset trawl warps set to mimic the wire measurement error with depth. A commercial fishing vessel, the F/V Sea Breeze, conducted side by side tows with the R/V Albatross IV to provide additional information on catch rates and species and was included as a covariate in the analysis.

The original design called for trials to be conducted in two principal depth zones chosen to reflect different degrees of trawl warp offset and species composition. Completion of two 48 hr sampling units was intended for each of the two depth zones. On the recommendation of industry representatives, a third area was included in the analysis. During the course of the experiment, each area was occupied for a 48 hr period. The cruise duration was shortened due to deteriorating weather conditions. For sampling locations, station selection procedures and sampling procedures, see Almeida (2003).

Analysis

The analysis was conducted in two phases. To test for overall treatment effects, a three way multivariate analysis of variance was conducted with Area, Gear, and Block as the main effects. I included an Area by Gear interaction effect. Analysis was restricted to 22 species selected for their importance in the catch and the catch of all species combined. The species examined in this report include spiny dogfish, barndoor skate, winter skate, little skate, smooth skate, thorny skate, Atlantic herring, silver hake, Atlantic cod, haddock, pollock, white hake, red hake American plaice, yellowtail flounder, winter flounder, witch flounder, redfish, goosefish, sea scallop, shortfin squid and longfin squid. Sea scallops are included in this analysis as an indicator of the bottom tending characteristics of the gear following initial indications that more benthic organisms and material was collected with the experimental treatment net in one area. To stabilize the variance I use a $\log_e \{x + c\}$ transform where c is a small constant. Univariate analyses of variance were also conducted for each species individually using a three way analysis (Area, Gear, Block) and the Area*Gear interaction with the Sea Breeze catch as a covariate. Two tailed tests of significance were used throughout.

Catches of all species were standardized by dividing by the area covered during a tow. Godo et al. (1990) indicated that catches scaled in proportion to doorspread in comparisons of research and commercial trawl gear. To calculate the effective fishing area of a tow, I therefore used the mean doorspread during the course of a tow after removing information from the first 5 minutes of the tow (Henry Milliken, NEFSC, personal communication) and the tow distance. For the F/V Sea Breeze, comparable information was not available and the mean doorspread was recorded by the vessel captain. During the course of the experiment, the length of the ground cables used by the Sea Breeze was increased, resulting in an increase in the mean doorspread from 60.4m to 76.8m. Distance towed for the R/V Albatross IV was determined from integrated GPS measurements taken throughout the tow. Comparable net mensuration information was not available for the F/V Sea Breeze and the tow distance was determined based on the mean tow speed over bottom and the tow time for each haul.

A total of 36 blocks were completed during the course of the experiment by the R/V Albatross IV yielding a total of 72 tows. The number of tows within each area is provided in Table 1. It was not possible for the F/V Sea Breeze to match all tows because of crew size limitations. However, at least one tow was made in each block by the commercial vessel. A total of 61 tows was completed by the Sea Breeze (Table 1).

Table 1. Number of tows by the Albatross IV by area for the control gear configuration (C), the experimental treatment (T) and for the F/V Sea Breeze.

Area 1			Area 2			Area 3		
C	T	SB	C	T	SB	C	T	SB
10	10	17	13	13	24	13	13	20

The following adjustments were made to account for missing information. For twelve Albatross IV tows, net mensuration data were not available to determine doorspread and the mean for the appropriate area/gear combination was used. In any instances where information on distance towed was missing for the R/V Albatross or the F/V Sea Breeze, the mean over all observations in that area was used. For the analyses of covariance, I substituted the catch information for the observed haul in that block for missing information when it was not possible for the F/V Sea Breeze to complete two tows within a block.

Results.

Estimates of the mean density (kg/km^2) for the 22 species examined and the mean density of all species are provided in Table 2. The mean catch of all species was highest in the experimental treatment in two of the three areas (Table 2). The result for the catch of all species was dominated by a limited number of species. In Area 1, higher catches by the treatment net for haddock strongly influenced this outcome. In Area 2, high catches in the experimental treatment of herring and spiny dogfish resulted in a higher total catch in this gear configuration. The estimated densities were higher for the treatment net in 57% of the area/gear/species combinations for which comparisons were possible despite the presumed suboptimal configuration of the gear.

Results of the Multivariate Analysis of Variance indicated a significant overall effect of area and gear on estimated density (Table 3). The effects of block and the area*gear interaction were not significant at the .05 level. The gear effect is of principal concern in this analysis. The results of univariate analyses of variance are provided in Table 3. The region effect was statistically significant for all species (Table 3). For 5 species, a significant gear effect is evident; estimated mean density was higher in the control gear configuration for smooth skate, sea scallops, and longfin squid while significantly higher density estimates were obtained for winter skate and for Atlantic herring. Significant area*gear interaction terms were found for the total species density and for yellowtail flounder.

Table 3. Estimates of mean density (kg/km²) for 22 species and all species combined by area with associated standard errors (in parentheses) for the control and experimental gear configurations for Albatross IV and for the F/V Sea Breeze.

Species	Area 1			Area 2			Area 3		
	Control	Treatment	Sea Breeze	Control	Treatment	Sea Breeze	Control	Treatment	Sea Breeze
Total	5312.7 (2119.09)	6668.12 (1714.17)	7970.72 (1569.79)	2103.23 (157.03)	4004.68 (949.56)	4098.75 (445.43)	1243.32 (202.78)	809.29 (89.22)	2487.89 (159.24)
Spiny Dogfish		6.11 (4.59)	10.15 (3.51)	107.63 (42.38)	469.62 (205.52)	611.77 (280.46)	8.71 (4.64)	1.88 (1.88)	7.01 (1.95)
Barndoor Skate			0.83 (0.83)	1.14 (1.14)		4.59 (2.41)	56.21 (19.67)	67.33 (25.02)	261.71 (31.19)
Winter Skate			7.69 (4.69)		1.74 (1.74)	0.53 (0.53)	9.16 (4.09)	97.55 (48.02)	220.09 (128.79)
Little Skate							94.03 (21.46)	98.99 (21.52)	808.93 (38.37)
Smooth Skate	41.42 (13.17)	22.80 (7.40)	127.17 (22.57)	3.71 (1.82)		15.45 (2.30)			4.47 (2.44)
Thorny Skate	81.27 (27.01)	81.56 (31.42)	146.35 (27.44)	1.34 (1.32)		8.28 (2.75)	1.64 (1.64)		13.17 (6.65)
Atlantic Herring	28.34 (8.02)	32.15 (5.93)	28.82 (8.59)	482.57 (131.07)	2196.76 (942.12)	1050.91 (282.36)	0.49 (0.27)	2.75 (1.19)	2.35 (0.93)

Silver Hake	94.10 (18.47)	122.43 (27.68)	127.78 (15.87)	672.56 (72.73)	792.64 (165.04)	1694.55 (232.26)	22.71 (3.96)	30.83 (6.04)	59.89 (14.55)
Atlantic Cod	267.01 (94.51)	205.35 (54.22)	439.42 (97.38)		3.51 (3.51)	3.02 (1.35)	9.74 (9.74)		1.26 (0.89)
Haddock	3393.70 (1774.96)	4789.77 (1431.53)	5148.56 (1209.65)	2.73 (2.73)	5.90 (4.54)	2.91 (1.32)		0.02 (0.01)	
Pollock	158.02 (1000.973)	121.67 (42.45)	199.06 (66.66)	5.05 (2.31)	1.96 (1.57)	3.73 (1.38)		0.17 (0.17)	0.23 (0.16)
White Hake	44.17 (12.57)	66.70 (20.43)	101.08 (13.13)	309.01 (39.55)	136.44 (30.65)	185.64 (21.77)	6.07 (2.86)	8.68 (4.70)	4.71 (1.52)
Red Hake	49.50 (10.22)	63.36 (13.94)	81.41 (14.06)	252.24 (26.83)	196.24 (31.63)	185.55 (21.72)	96.71 (14.59)	144.99 (25.90)	268.39 (23.21)
American Plaice	3.71 (1.28)	6.87 (2.20)	6.73 (1.55)	85.28 (11.56)	48.26 (9.94)	85.12 (7.77)	0.46 (0.31)	0.74 (0.74)	0.08 (0.08)
Yellowtail Flounder	1.57 (0.96)		1.04 (0.39)				0.32 (0.32)	2.00 (1.06)	1.49 (0.51)
Winter Flounder			0.42 (0.42)				58.66 (10.23)	74.61 (16.00)	133.22 (16.29)_
Witch Flounder	16.20 (6.12)	21.56 (8.52)	107.66 (18.83)	10.37 (1.94)	9.34 (4.42)	55.84 (4.14)	1.21 (0.89)	2.64 (1.79)	21.06 (3.68)
Redfish	1022.03 (348.86)	927.28 (289.39)	1197.16 (351.89)	28.27 (14.76)	49.66 (18.90)	46.38 (18.75)		0.45 (0.45)	
Goosefish	4.78 (4.70)	10.59 (10.58)	102.97 (31.00)	26.77 (9.45)	17.50 (7.64)	104.61 (8.71)	47.81 (9.66)	20.38 (8.73)	294.23 (23.74)

Table 4. Results of univariate analysis of variance for 22 species and the total species density for the effects of area, gear, block, and the area*gear interaction.

Species	Area	Gear	Block	Area * Gear	Covariate
Total	69.61**	1.82	3.27**	6.71**	33.12**
Spiny Dogfish	29.50**	1.13	0.76	2.07	3.58**
Barndoor Skate	51.55**	1.48	1.70	0.49	1.59
Winter Skate	26.08**	7.33**	0.76	4.29*	0.04
Little Skate	1501.64**	0.27	1.97**	0.24	2.68
Smooth Skate	57.02**	5.22**	0.75	1.82	0.36
Thorny Skate	62.78**	1.15	1.18	0.01	2.80
Atlantic Herring	164.43**	17.43**	3.82*	2.06	26.87**
Silver Hake	146.01**	2.65	0.98	0.63	35.86**
Atlantic Cod	126.51**	0.14	0.80	0.97	0.78
Haddock	424.34**	2.35	1.30	0.66	5.03**
Pollock	62.24**	0.04	2.41**	1.23	24.29**
White Hake	47.68**	1.79	0.97	0.29	0.0
Red Hake	25.88**	0.09	2.25	1.34	10.39**
American Plaice	125.66**	0.27	1.09	1.48	8.65**
Yellowtail Flounder	2.64**	0.03	1.03	3.86**	3.08*
Winter Flounder	1987.43**	0.86	1.89	0.76	0.90
Witch Flounder	12.96**	0.26	0.99	1.03	4.25**
Redfish	339.20**	0.19	3.31**	0.45	21.20**
Goosefish	13.28**	2.73	0.94	2.31	1.23
Sea Scallop	319.68**	10.93**	3.02**	9.67**	16.00**
Shortfin Squid	21.98**	1.99	0.98	1.09	0.01
Longfin Squid	258.30**	9.41**	1.46	3.88*	9.03**

* $p < 0.05$ ** $p < 0.01$

Discussion

Evidence for systemic reductions in catch for a complex of fish and invertebrate species with the use of presumed suboptimal gear configurations are not apparent in this experiment. The results of a multivariate analysis of variance does indicate that significant gear effects do occur. Further examination of catch rate for five species indicating statistically significant differences shows that for two of the five, the mean density was higher in the treatment gear and higher for the control in three of the remaining cases. The design of this experiment does not permit separation of the effects of the trawl warp offset from other gear characteristics. The door spread in the control gear configuration was greater than in the experimental treatment configuration and there is some indication from the collection of benthic organisms that the bottom tending characteristics of the control were different from those of the treatment. This is reflected in the higher catches of scallops in the control gear, most notably in area three. This presumably also has implications for the catches of strongly demersal fish species. In the present analysis, the higher catches of smooth skate may be a result of this effect although winter skate catches were higher in the treatment.

Although the characteristically high variability in catches of fish species due to their highly contagious distribution patterns complicates the design and interpretation of comparative fishing trials, the tests performed here did have sufficient power to discern differences in overall gear effects and for selected individual species. In the present analysis, it was not possible to reject the null hypothesis of no gear effect for the complex of regulated groundfish species. Several groundfish species showed results that warrant further consideration including white hake and American plaice both of which showed higher catches in the control gear than in the experimental treatment in Area Two. However, these apparent gear effects were not consistently observed in the other areas and the overall result was not statistically significant.

References

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